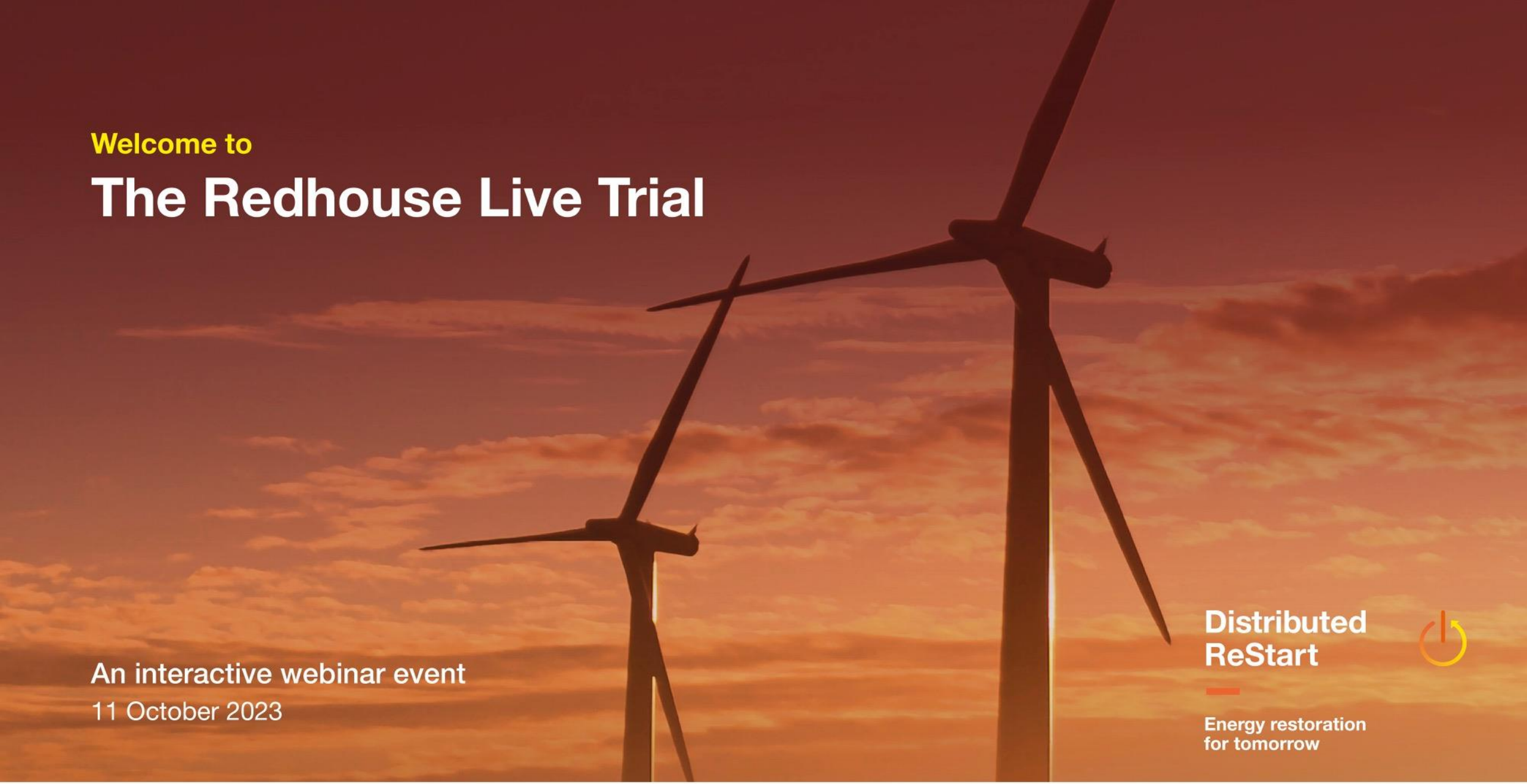


Welcome to

The Redhouse Live Trial

An interactive webinar event

11 October 2023

Distributed ReStart

Energy restoration for tomorrow

In partnership with:

tnei

SP Energy Networks

nationalgridESO

Agenda

Slido: Restart

Project overview
Michael Kenny – Project and Organisational, Systems and Telecoms (OST) Lead

Live trials overview
Jack Haynes – Power Engineering and Trials (PET) Lead

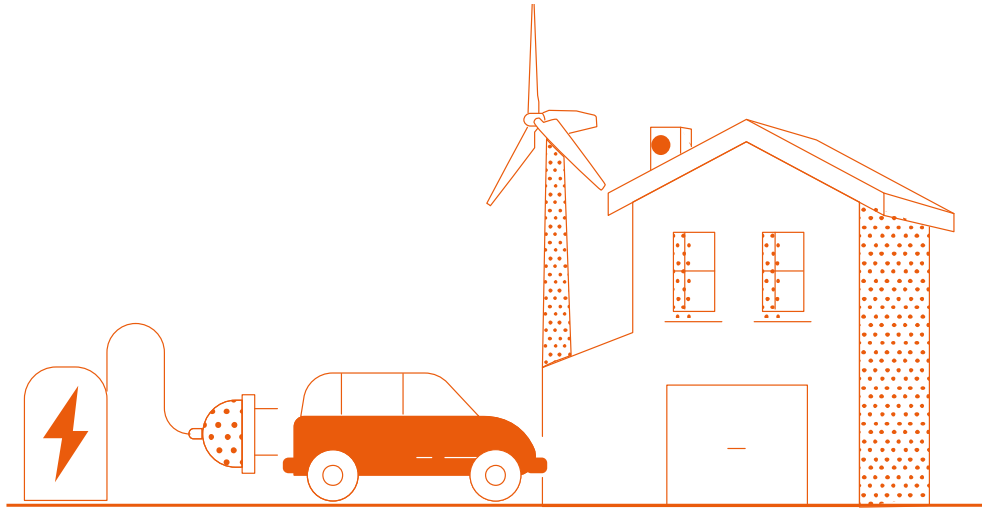
The goal and scope of the Redhouse live trial
Jack Haynes

Highlights of the Redhouse live trial
Jack Haynes

What's been proven
Jack Haynes

Transition to business as usual (BAU)
Michael Kenny

Q&A
Michael Kenny



Project overview

Michael Kenny

Project and OST Lead

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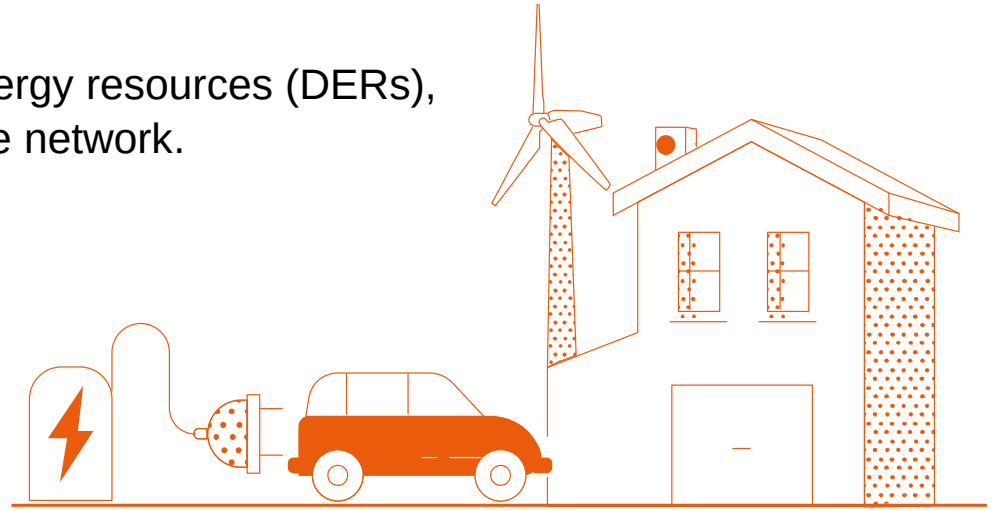
Distributed ReStart

Energy restoration for tomorrow

What is the Distributed ReStart project?

Slido: Restart

- Launched in 2019, this innovation project is a partnership between National Grid Electricity System Operator (ESO), SP Energy Networks and TNEI (a specialist energy consultancy).
- While a total shutdown of the electricity network is extremely unlikely, it's essential we have the capability for rapid restoration (AKA black start).
- The conventional approach, both here and in many countries, uses large fossil fuel power stations for restoration.
- Distributed ReStart has been exploring how we can use distributed energy resources (DERs), such as wind, solar, hydro, biomass and battery to restore power to the network.
- Making renewables and other DER viable for electricity system restoration is essential for achieving net zero, improving the resilience of our network and reducing costs for consumers.



Organisational Outputs:

- New strategic command and control model required with significantly enhanced role for DNOs and new capability for DER
- Full end to end process documentation including testing via desktop exercises and creation of an example distribution restoration zone plan
- Change assessment for all parties involved in the restoration process in final report

ESO continue to coordinate national restoration including instructing the start of plans whilst DNOs lead locally. The DNO makes use of a control system for management of real time frequency, voltage and generator dispatch

TO

- Transmission network switching actions
- Data provision to DNO
- Co-develop transmission level strategy
- Increased number of new DRZ

NGESO

- Declare Black Start
- National strategy
- Regional strategy
- Instruct DRZ start
- Instruct transmission restoration route
- Instruct power island growth outside of DRZ

DNO

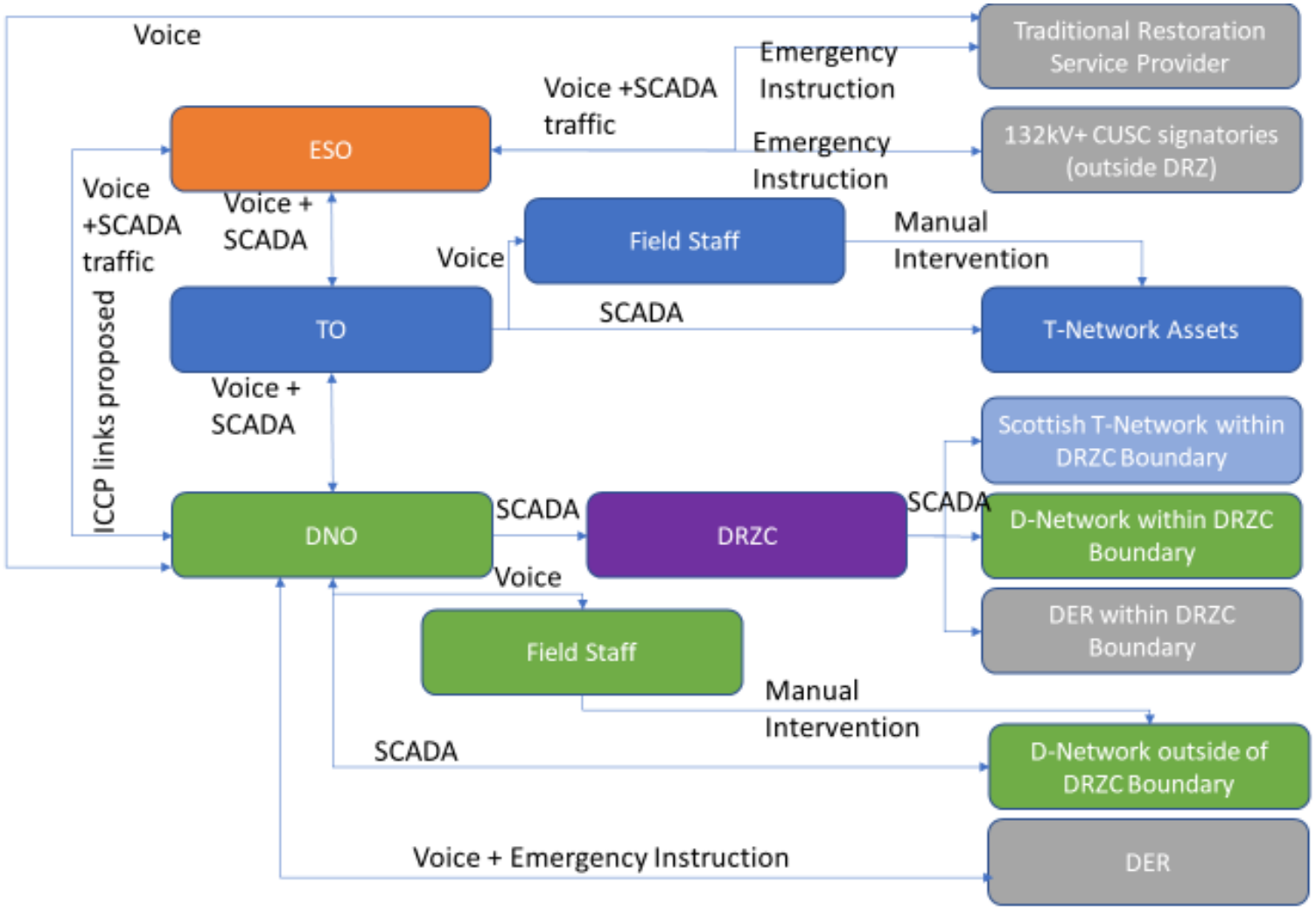
- Declare and instruct restoration to service providers
- Develop local restoration strategy
- Distribution network switching actions
- Local voltage and frequency management

DER

- Multiple individual providers deliver different services to the restoration zone
- Anchor DER provides the initial voltage and frequency source
- Top-up service providers support power island growth

Systems & Telecommunications outputs:

- Full specification of the interfaces and communications methods between organisations
- Functional specification created detailing all technical and non-technical aspects for a power resilient communications network which is able to facilitate the control system requirements
- Detailed cyber security assessment of the control system and communications network including recommendations for roll-out GB wide
- Technology agnostic approach to enable lowest cost GB wide roll-out based upon existing infrastructure wherever possible



Procurement & Compliance final recommendations following stakeholder and DNO engagements

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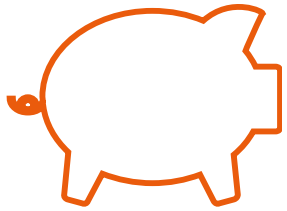
Procurement Lead

ESO to lead until an industry decision is made, then handover accordingly

Section 3.3 in the P&C final report



Settlement & Funding

ESO to pay DER contracted costs but DNO to recover their network upgrade costs through price control

Section 9 in the P&C final report

Contracting

Open and transparent Tripartite contract between ESO, DNO/DSO and DERs – both AG and TUS

Section 10 in the P&C final report and Appendix 2

Codes

Recommendations will be reviewed as part of the GC0156 code modification process

Section 12 in the P&C final report and Appendix 3

The options, criteria, stakeholder engagement and decisions are elaborated in the P&C final report

Live trials overview

Jack Haynes
Power Engineering and Trials (PET) Lead

Distributed ReStart

Energy restoration for tomorrow

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Power Engineering and Trials motivation

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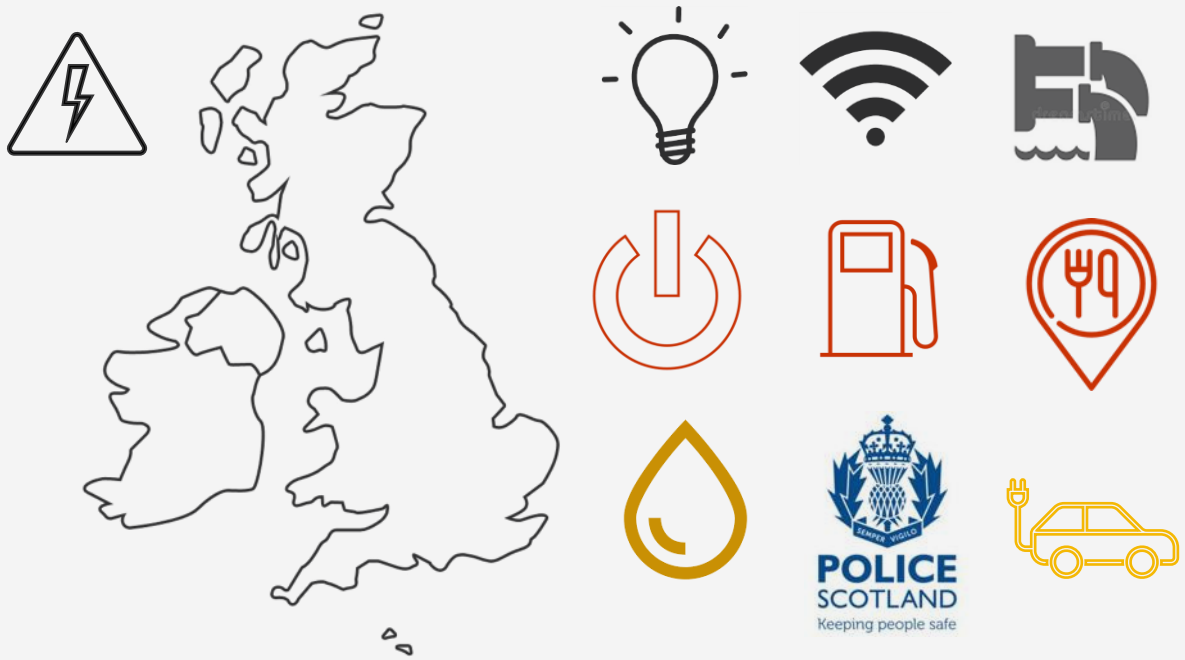
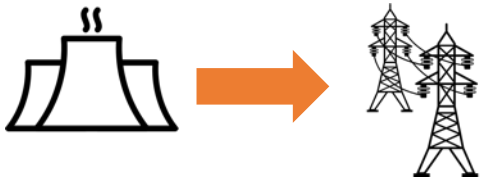


nationalgridESO

SP Energy Networks

Today | 5-7 days for restoration using traditional methods

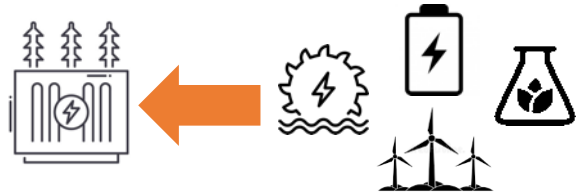


Closing of coal/gas stations means a need to rely on renewables for restoration

Need to tap into distributed generator resource of which there are 1000s connected in the U.K

Reduce restoration timeframe and monetise availability

After D-Restart | <1-3 days for restoration using DRZs



1) Demonstrate ability of DERs such as wind, hydro, biomass or batteries to start and maintain power islands
2) Increase number of revenue streams for generation owners via commercialisation of restoration availability
3) Reduce black start restoration timeframe from 5-7 days to potentially hours – 3 days subject to rollout
4) Set global benchmark/template for distributed restoration zones (DRZs) through world first testing
5) Further expand the portfolio of renewable generation benefits in pursuit of Net-Zero

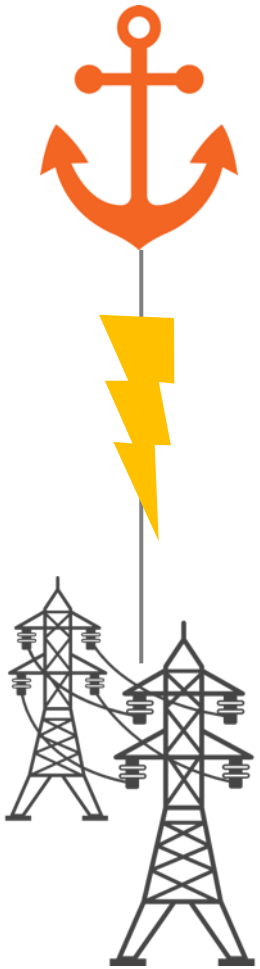
Our Earlier Trials

Slido: Restart

Kendoon Hydro
April 22

Energised up to 275kV from 11kV 13MVA

Generator & measure BLPU of Hydro



Stevenscroft Biomass
June 22

Energised up to 400kV from 33kV 53MVA

Generator & measure BLPU of Biomass

The goal and scope of the Redhouse live trial

Jack Haynes
Power Engineering and Trials (PET) Lead

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Energy restoration for tomorrow

The goal and scope of the world-first Redhouse live trial

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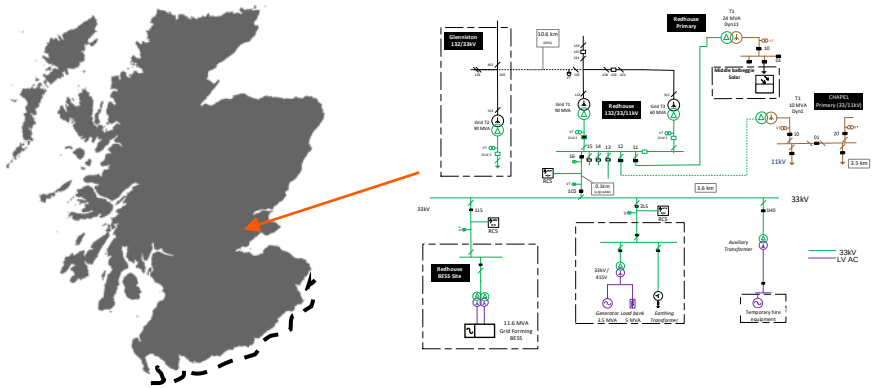
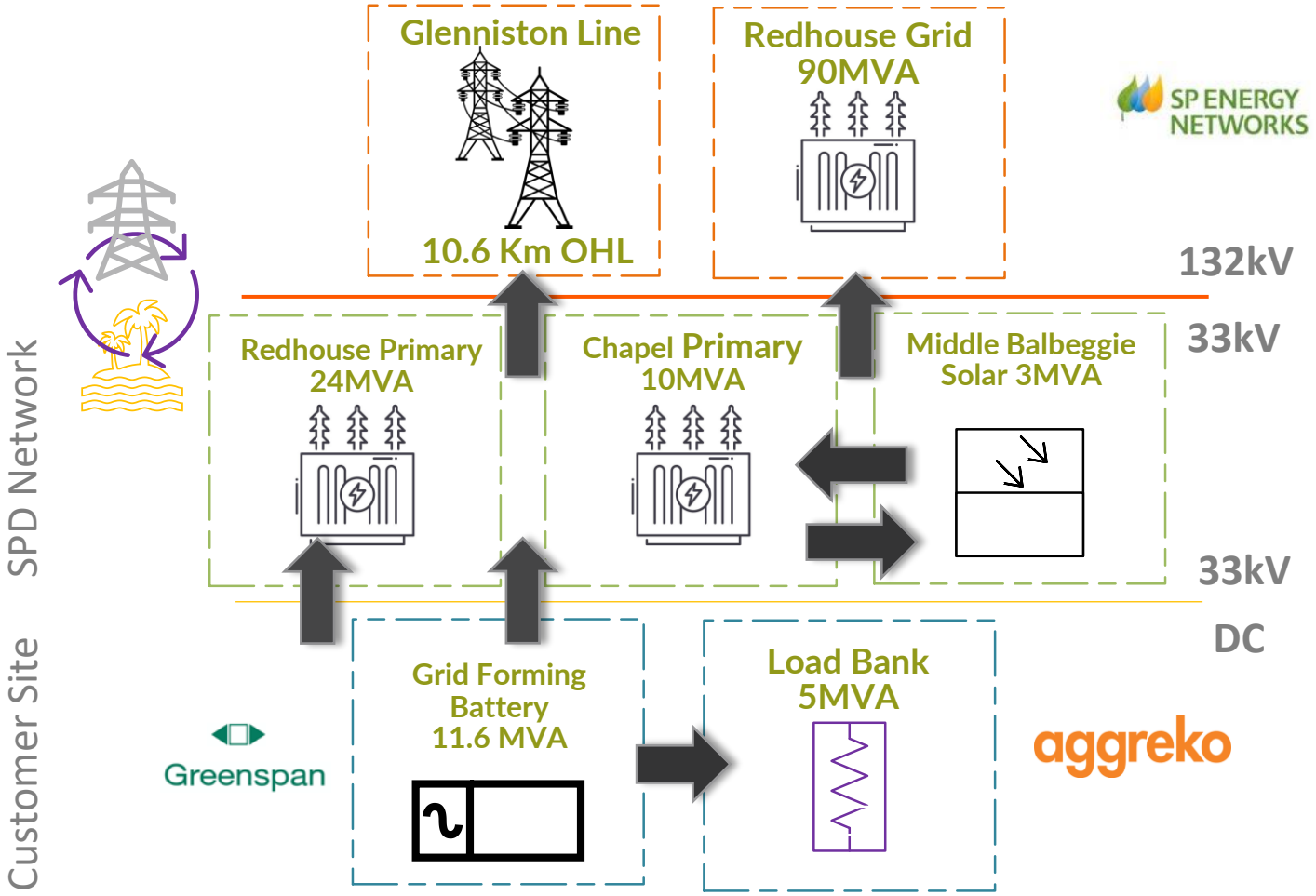
- The project's two previous live trials had proven the concept of using **biomass** and **hydro** to start-up and control a power island or 'distribution restoration zone' (DRZ).

- The goal of this trial was to use **a non-synchronous converter-connected battery energy storage system (BESS)** to restart the DRZ.





Redhouse live trial proves battery restoration in practice

Slido: Restart

Battery Energy Storage Systems (BESS) **can be utilised as anchor generators to start, maintain and control power islands very effectively**, with the aid of diesel gensets or without

They **can energise both Distribution & Transmission transformers & lines** and are much more effective at doing so when **Point on Wave (POW)** switching is active

The **Block Load Pickup Capability of BESS** when compared to synchronous generators of the same capacity is **far superior** and, in our case, needs to be calculated as opposed to measure due to its ability to outperform the biggest load step we could implement (4MW)

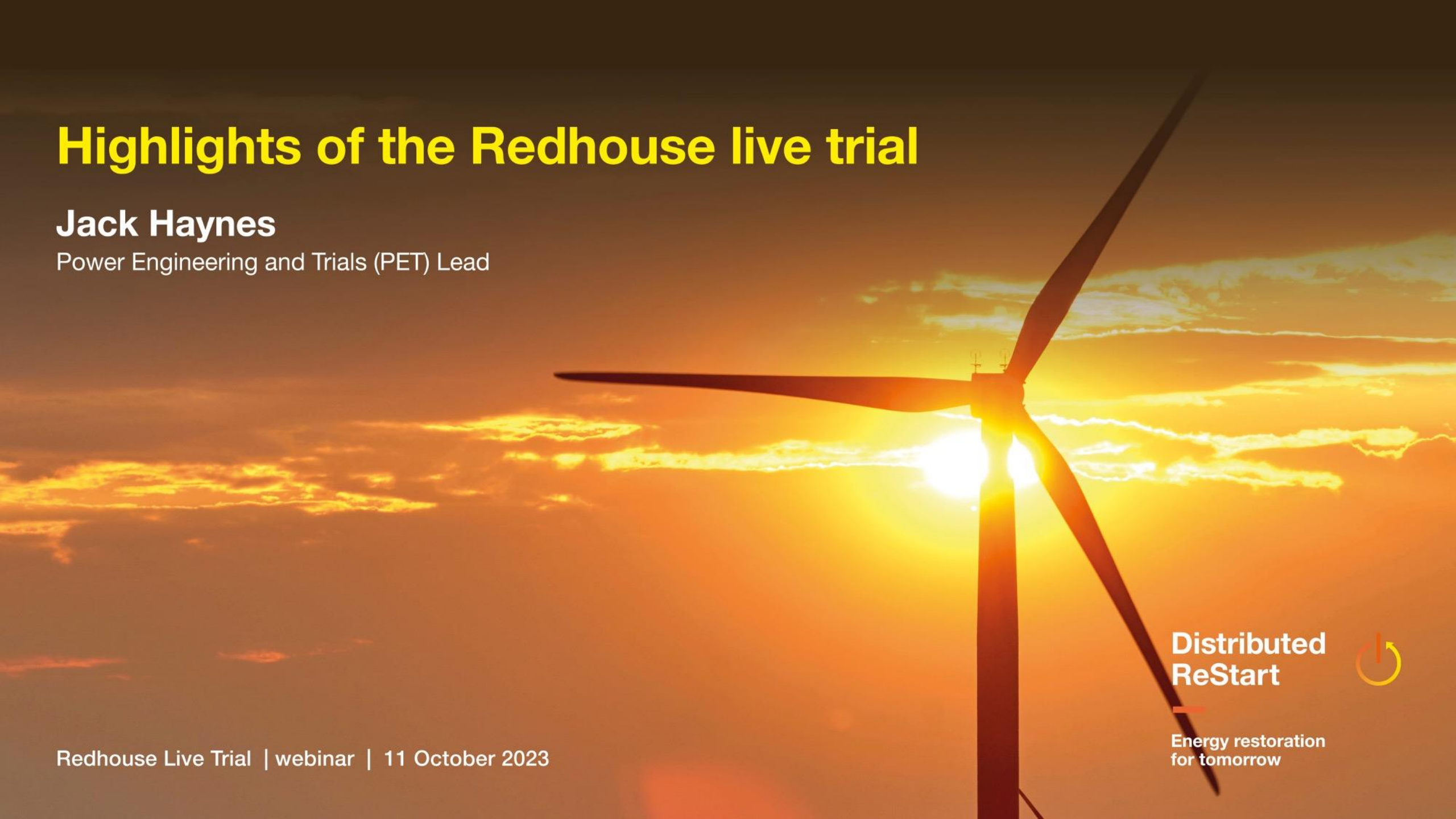
The **DRZC can automate the start-up and operation** of the BESS system and can utilise its functionality to **resynch with the intact Grid**

The island assets can be used together as a **Dynamic Virtual Power Plant (DVPP)** and dispatch load or generation as needed when connected to the grid

Ultimately, these world-first tests set a precedent for the use of BESS assets to be used, not just in the UK but around the world, as viable network restoration service providers.

Highlights of the Redhouse live trial

Jack Haynes
Power Engineering and Trials (PET) Lead



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Specific highlights from the Redhouse live trial

Slido: Restart

4MW Instantaneous load step (Approx. 2000-3000 homes)

8MW BESS Capacity

Operational limits observed with 1% droop control

Far superior to synch machines of same capacity (500%+ better)

Specific highlights from the Redhouse live trial

Slido: Restart

‘Hard’ switching without POW were attempted

Switching with POW performance compared

Both switches successful

Far more repeatable and reliable when POW engaged

Specific highlights from the Redhouse live trial

Slido: Restart

DRZC monitors both sides of the synch breaker (island and grid)

Drives island V,F and Phase angle to be inline with Grid

Arms CheckSynch for control engineer

Executes seamless closure to leave behind synched grid

What's been proven

Jack Haynes
Power Engineering and Trials (PET) Lead

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Energy restoration for tomorrow

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Redhouse live trial proves battery restoration in practice

Slido: Restart

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Transition to business as usual (BAU)

Michael Kenny
Project and OST Lead

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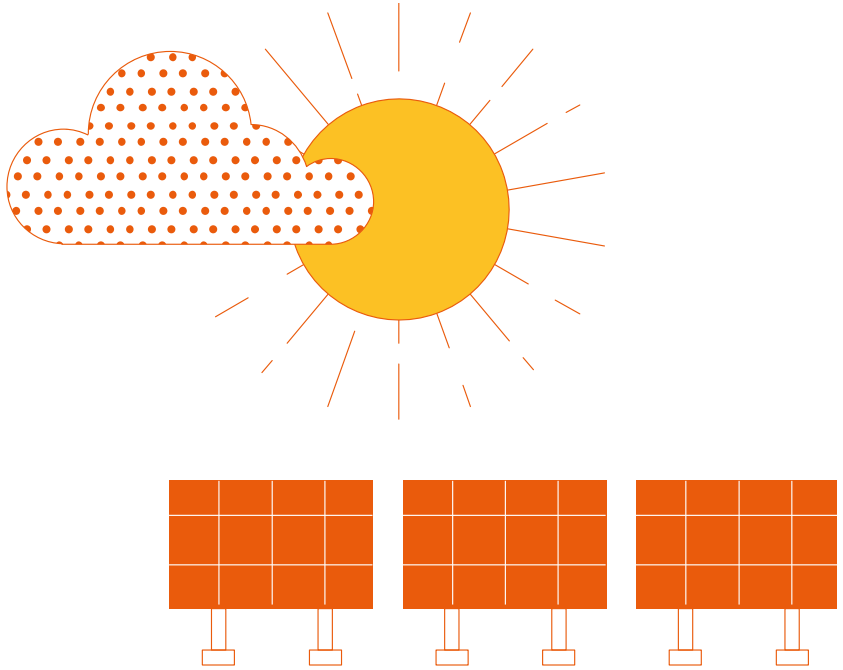
The project has now transitioned to BAU

Slido: Restart

- With the project's transition to business as usual (BAU), the concept of providing restoration services from DERs is now becoming a reality based on the learnings from our live trials.
- New tenders for the South East and Northern regions were launched in 2022 and interest from DERs was high.
- Compared to previous restoration tenders, where around 2-3 technology types bid, there were expressions of interest from at least 7 different technology types including wind/batteries/solar/hydro.
- By successfully transitioning to BAU, the project has created a 'blueprint' of recommendations for the industry to incorporate restoration from DERs.



Slido: Restart

Q&A

Michael Kenny
Project and OST Lead

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Energy restoration for tomorrow

Thank you

For more details, please visit Distributed ReStart on the ESO website.

On our website you can:

- contact us on our email address restart@nationalgrid.com
- get regular updates by subscribing to our emails
- browse our documents library which contains all our reports and publications.

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